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(54) **METHOD FOR MANUFACTURING FOAM MOLDED BODY**

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(58) **Field of Classification Search**
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(Continued)

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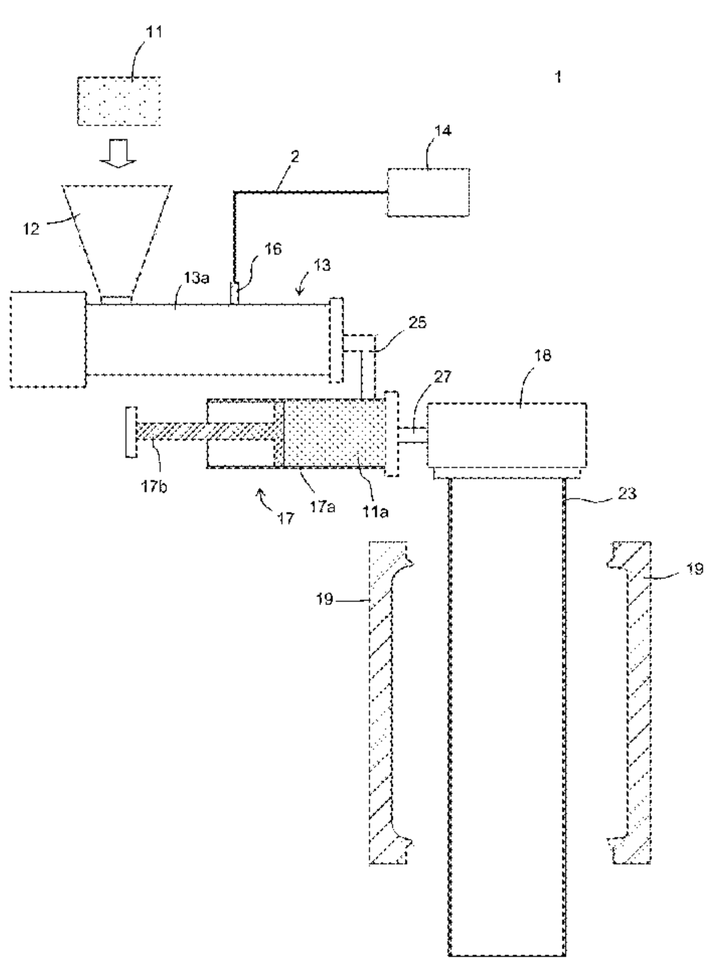
(57) **ABSTRACT**

Provided is a method for manufacturing a foam molded body that can make a shape of bubbles close to a perfect circle. According to the present disclosure, a method for manufacturing a foam molded body, including a step of forming a foam parison from a melt-kneaded resin obtained by melting and kneading a raw material resin and a foaming gas in a cylinder of an extruder and molding the foam parison to obtain the foam molded body, wherein the foaming gas contains 0.1 to 1.0% of argon, is provided.

1 Claim, 3 Drawing Sheets



(51) **Int. Cl.**
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C08J 9/12 (2006.01)

(58) **Field of Classification Search**
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See application file for complete search history.

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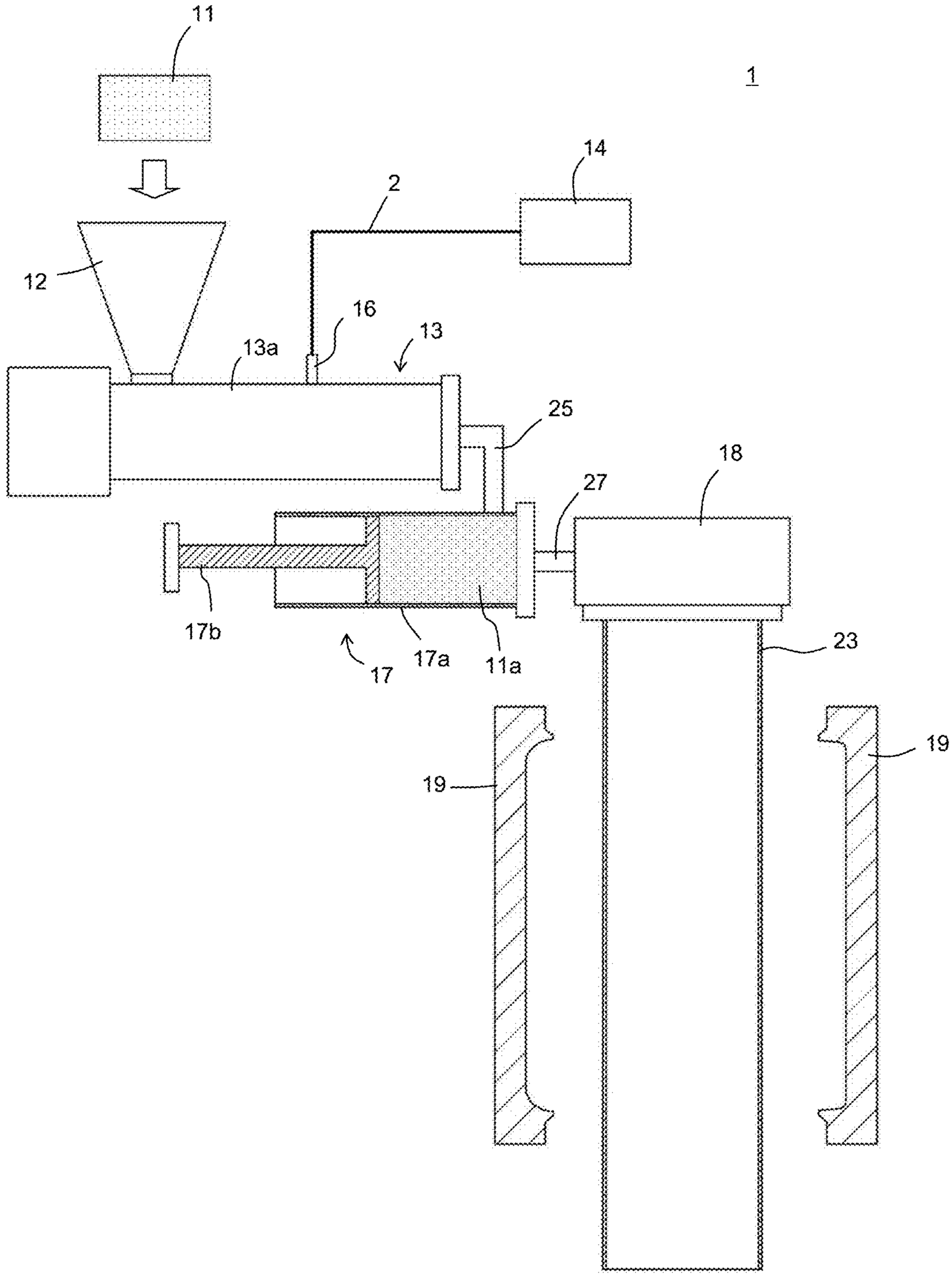
Fig.1



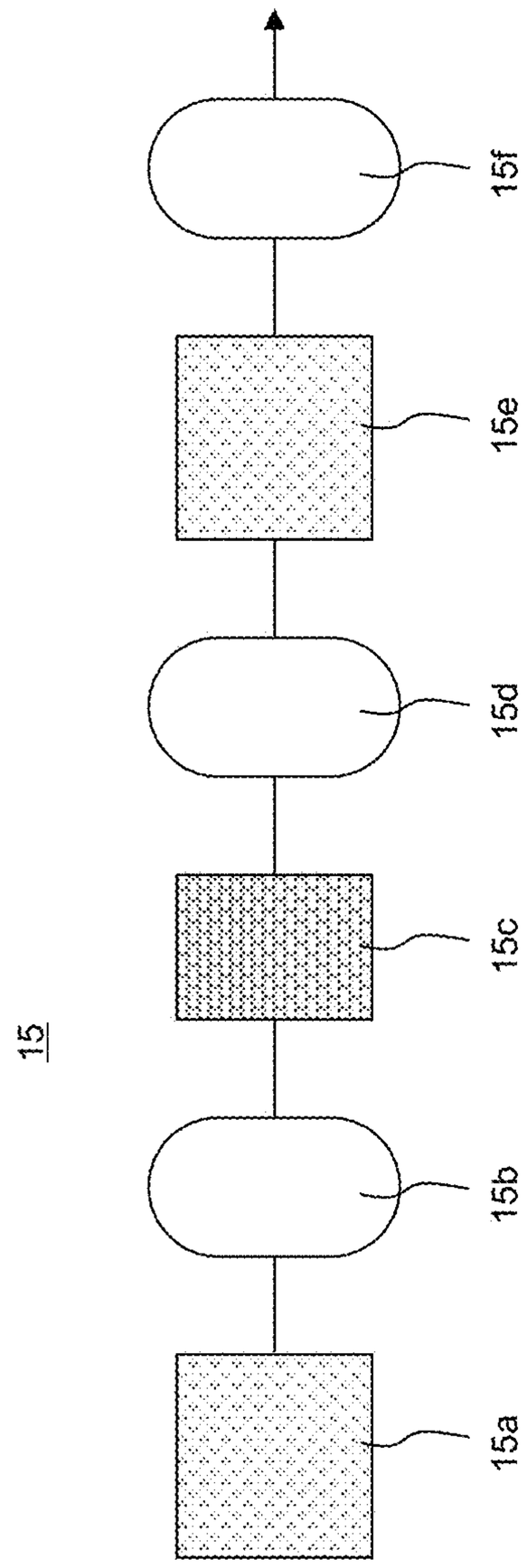


Fig. 2

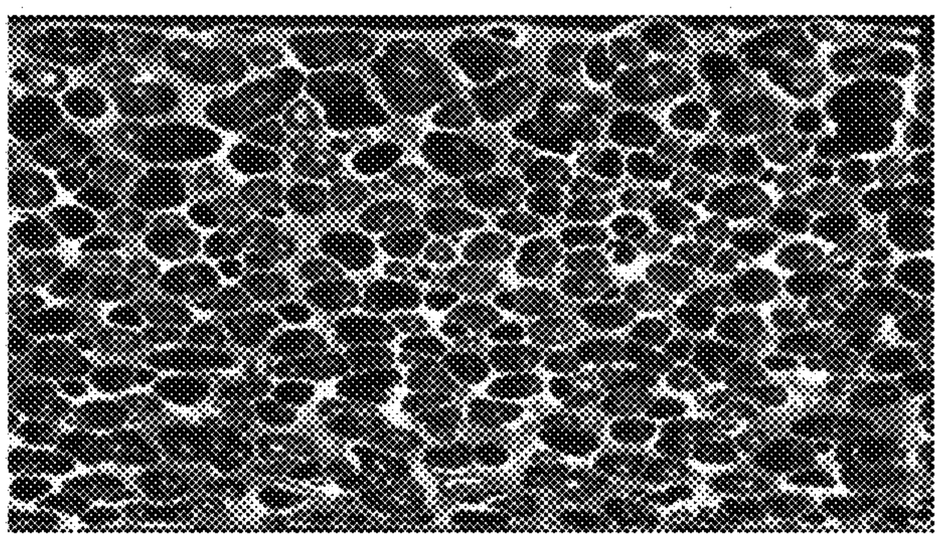


Fig. 3A

Example 1

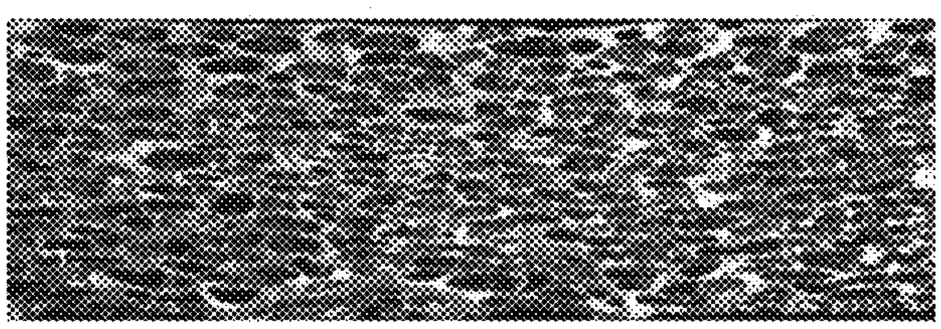


Fig. 3B

Comparative Example 1

METHOD FOR MANUFACTURING FOAM MOLDED BODY

TECHNICAL FIELD

The present invention relates to a method for manufacturing a foam molded body.

BACKGROUND ART

A tubular air conditioning duct for passing air is used, for example, in an air conditioner of an automobile and the like.

A foam molded body using a foamed resin obtained by foaming thermoplastic resin with a foaming gas is known as an air conditioning duct. The foam molded body can achieve both of high heat insulation and light weight, and the demand therefor is increasing.

A widely known method for manufacturing such a foam molded body is a blow molding method in which foamed resin in a molten state is clamped with a split mold, and air is blown into the interior to expand the resin (Patent Literature 1).

CITATION LIST

Patent Literature

Patent Literature 1: JP-A-2012-030498

SUMMARY OF INVENTION

Technical Problem

By the way, the shape of bubbles in the foam molded body is preferably close to a perfect circle because the foam molded body has higher heat insulation as the shape of bubbles approaches a perfect circle. However, the shape of bubbles tends to become longer in the direction along the resin flow, and it is not easy to make the shape of bubbles close to a perfect circle.

The present invention has been made in view of such circumstances and provides a method for manufacturing a foam molded body capable of making the shape of bubbles close to a perfect circle.

Solution to Problem

According to the present invention, a method for manufacturing a foam molded body, comprising a step of forming a foam parison from a melt-kneaded resin obtained by melting and kneading a raw material resin and a foaming gas in a cylinder of an extruder and molding the foam parison to obtain the foam molded body, wherein the foaming gas contains 0.1 to 1.0% of argon, is provided.

As a result of intensive studies by the present inventors, it has been found that the shape of bubbles approaches a perfect circle when the foaming gas contains 0.1 to 1.0% of argon, and the present invention has been derived therefrom.

Hereinafter, various embodiments of the present invention are exemplified. The following embodiments can be combined with each other.

Preferably, in the method described above, the foaming gas contains 98.0 to 99.9% of nitrogen.

Preferably, in the method described above, the foaming gas is a gas obtained by using an adsorbent to remove oxygen from air.

According to another viewpoint of the present invention, provided is a method for manufacturing a foam molded body, comprising a step of forming a foam parison from a melt-kneaded resin obtained by melting and kneading a raw material resin and a foaming gas in a cylinder of an extruder and molding the foam parison to obtain the foam molded body, wherein the foaming gas is a gas obtained by removing oxygen from air with an absorbent.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an example of a foam blow molding machine **1** that can be used in the method for manufacturing a foam molded body according to the embodiment of the present invention.

FIG. **2** is a detailed configuration of a nitrogen gas generation unit **15** in FIG. **1**.

FIG. **3**A is a cross-sectional photograph of the foam molded body of Example 1, and

FIG. **3**B is a cross-sectional photograph of the foam molded body of Comparative Example 1.

DESCRIPTION OF EMBODIMENTS

Hereinafter, embodiments of the present invention will be described. Various characteristics described in the following embodiments can be combined with each other. In addition, the invention is independently established for each characteristic.

The method for manufacturing a foam molded body according to an embodiment of the present invention comprises a step of forming a foam parison from a melt-kneaded resin obtained by melting and kneading a raw material resin and a foaming gas in a cylinder of an extruder and molding the foam parison to obtain the foam molded body, wherein the foaming gas contains 0.1 to 1.0% of argon.

The method of this embodiment can be performed using the foam blow molding machine **1** illustrated in FIG. **1**. The foam blow molding machine **1** comprises a hopper **12**, an extruder **13**, an injector **16**, an accumulator **17**, a head **18**, and a split mold **19**. The extruder **13** and the accumulator **17** are connected via a joint pipe **25**. The accumulator **17** and the head **18** are connected via a joint pipe **27**.

Hereinafter, each component will be described in detail.

<Hopper **12**, Extruder **13**>

The hopper **12** is used to inject the raw material resin **11** into a cylinder **13***a* of the extruder **13**. The form of the raw material resin **11** is not particularly limited, but is typically pellets. The raw material resin **11** is injected into the cylinder **13***a* from the hopper **12** and then heated and melted in the cylinder **13***a* to become a molten resin. Further, by the rotation of the screw arranged in the cylinder **13***a*, the resin is conveyed toward the tip of the cylinder **13***a*. The screw is arranged in the cylinder **13***a* and conveys the molten resin while kneading the molten resin by the rotation thereof. A gear device is provided at the base end of the screw, and the screw is driven to rotate by the gear device.

<Injector**16**, Gas Supply Device**14**, Nitrogen Gas Generation Unit**15**, Foaming Gas>

The cylinder **13***a* is provided with the injector **16** for injecting foaming gas into the cylinder **13***a*. The gas supply device **14** is connected to the injector **16** via a pipe **2**.

The foaming gas is injected into the cylinder **13***a* through the injector **16** while the pressure and flow rate of the foaming gas are adjusted in the gas supply device **14**. The foaming gas is preferably injected into the cylinder **13***a* in the state of supercritical fluid.

The gas supply device **14** is a device that supplies a foaming gas, and may be a device that supplies a gas from one or a plurality of cylinders as a foaming gas, or may be a device that supplies a gas obtained by extracting a desired component from air as a foaming gas.

The foaming gas only needs to contain 0.1 to 1.0% of argon, and the remaining components include gases contained in air, such as nitrogen, oxygen and carbon dioxide. By performing foam molding using such a foaming gas, the roundness of the bubbles in foam molding is increased.

The argon concentration in the foaming gas is specifically, for example, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0%, and may be a value in the range between any two of these values exemplified here. The foaming gas preferably contains 98.0 to 99.9% (preferably 99.0 to 99.9%) of nitrogen. The nitrogen concentration in the foaming gas is specifically, for example, 98.0, 98.1, 98.2, 98.3, 98.4, 98.5, 98.6, 98.7, 98.8, 98.9, 99.0, 99.1, 99.2, 99.3, 99.4, 99.5, 99.6, 99.7, 99.8, 99.9%, and may be a value in the range between any two of these values exemplified here. The total concentration of nitrogen and argon in the foaming gas is, for example, 99 to 100%, specifically, for example, 99, 99.9, 99.99, 99.999, 99.9999, 100% and may be a value in the range between any two of these values exemplified here.

The gas supply device **14** is preferably a nitrogen gas generation unit **15** which removes oxygen from air by using an adsorbent. Oxygen can be efficiently removed by such a nitrogen gas generation unit, but argon is hardly removed or is not removed at all, so that at least a part of argon contained in air remains in the obtained foaming gas. Therefore, the foaming gas containing 0.1 to 1.0% of argon can be obtained without adding argon separately. Examples of the adsorbent include microporous adsorbent such as activated carbon and zeolite.

As shown in FIG. **2**, the nitrogen gas generation unit **15** comprises, for example, a compressor **15***a*, a tank **15***b*, a nitrogen gas generator **15***c*, a buffer tank **15***d*, a compressor **15***e*, and a buffer tank **15***f*.

The compressor **15***a* is a facility for compressing air and is used to obtain a high-pressure air in a manufacturing factory. The tank **15***b* is a facility for storing the compressed air produced by the compressor **15***a*. When the factory in which the nitrogen gas generation unit **15** is installed is already equipped with the facility corresponding to the compressor **15***a* and the tank **15***b*, it is not necessary to separately prepare the compressor **15***a* and the tank **15***b*.

The compressed air stored in the tank **15***b* is used to operate the nitrogen gas generator **15***c*. The nitrogen gas generator **15***c* is a facility that removes oxygen from the compressed air by using an adsorbent. The nitrogen gas is accumulated in the buffer tank **15***d* after its purity is increased. The compressor **15***e* is used to increase the pressure of the gas stored in the buffer tank **15***d*, and the buffer tank **15***f* is a facility provided to store the gas whose pressure is increased by the compressor **15***e*.

In addition, since a large amount of the foaming gas is consumed at the start of production (the total consumption is small), branching the pipe **2** and connecting it to a nitrogen cylinder can achieve overall downsizing and can also ensure stability of the facility.

Since the nitrogen gas generator **15***c* is a facility for removing oxygen from air, it is impossible to obtain a discharge pressure higher than the pressure of raw air for operation The pressure of the air compressed by the compressor **15***a* is about 0.7 MPa, and the discharge pressure of the nitrogen gas generator **15***c* is actually about 0.6 MPa. In Japan, when the facility increases the pressure to 1.0 MPa or more, it is regarded as a "high pressure gas production facility" to become difficult to sell. Further, since there is no demand for increasing the pressure of nitrogen to 1.0 MPa or more to consume, there is almost no nitrogen gas generator applicable for increasing the pressure.

On the other hand, the injector **16** is assumed to be supplied with a gas from the cylinder, and therefore requires a gas pressure of 1.5 MPa or more in order to confirm the residual quantity of the gas in the cylinder and to ensure the stability of increasing the pressure. Therefore, the compressor **15***e* for increasing the pressure is required immediately after the nitrogen gas generator **15***c*, that is, immediately before the injector **16**. If the compressor **15***e* is too large, the buffer tank **15***d* becomes empty immediately and stable operation cannot be performed. If the compressor **15***e* is too small, it takes time to fill the buffer tank **15***f*. It is necessary to select compressor **15***e* having an appropriate size.

<Accumulator **17**, Head **18**>

The melt-kneaded resin obtained by melting and kneading the raw material resin and foaming gas are extruded from a resin extrusion port of the cylinder **13***a* and injected into the accumulator **17** through the joint pipe **25**. The accumulator **17** comprises a cylinder **17***a* and a piston **17***b* slidable inside the cylinder **17***a*, and the melt-kneaded resin **11***a* can be stored in the cylinder **17***a*. Then, by moving the piston **17***b* after a predetermined amount of the melt-kneaded resin **11***a* is stored in the cylinder **17***a*, the melt-kneaded resin **11***a* is extruded through the joint pipe **27** from a die slit provided in the head **18** to form a foam parison **23**. The shape of the foam parison **23** is not particularly limited and may be cylindrical or sheet.

<Split Mold **19**>

The foam parison **23** is guided between a pair of split molds **19**. A foam molded body is obtained by molding the foam parison **23** using the split mold **19**. The molding method using the split mold **19** is not particularly limited. The method may adopt blow molding in which the foam parison is molded by blowing air into cavity of the split molds **19**, or vacuum molding in which the foam parison **23** is molded by decompressing the cavity of the split molds **19** from an inner surface of the cavity, and may adopt a combination thereof.

EXAMPLES

1. Production of Foam Molded Body

Experimental Example 1

The foam molded body was produced using the foam blow molding machine **1** shown in FIG. **1**, and foam moldability was evaluated. The inner diameter of the cylinder **13***a* of the extruder **13** was 50 mm, and L/D was 34. As the raw material resin, a propylene homopolymer (manufactured by Borealis AG, product name "Daploy WB140") and a long chain branched polypropylene (manufactured by Nippon Polypro Co., product name "EX6000K") at a mass ratio of 30:70 were mixed. 1.0 part by weight of LDPE-based masterbatch (manufactured by Dainichiseika Kogyo Co., Ltd., product name "Finecell Master P0217K") containing 20 wt % of sodium hydrogencarbonate-based foaming agent as a nucleating agent, and 1.0 part by weight of LLDPE-based masterbatch containing 40 wt % of carbon black as a colorant were added to 100 parts by weight of the resin. The temperature of each part was controlled so that the

temperature of the foam parison **23** was 190 to 200° C. The number of rotations of the screw was 60 rmm, and the extrusion rate was 20 kg/hr.

As the foaming gas, a gas generated by the nitrogen gas generation unit **15** shown in FIG. **2** was injected into the cylinder **13***a* via the injector **16**. The nitrogen gas generator **15***c* adopts a PSA system that adsorbs oxygen using a microporous adsorbent. The total concentration of nitrogen and argon was 99.990%. Since the adsorbent removes little or no argon, the argon concentration in the foaming gas of Example 1 is 0.1 to 1.0%.

The foam parison formed under the above conditions was used and placed between split molds for molding a cylindrical molded body. Then, after the split molds were clamped, blow molding was performed by blowing air at a pressure of 0.1 MPa into the foam parison to form a cylindrical foam molded body having the diameter of 50 mm, the height of 100 mm and the thickness of 5 mm.

Comparative Example 1

In Comparative Example 1, a foam molded body was produced in the same manner as in Example 1, except that the gas from the nitrogen gas cylinder, which was filled with the nitrogen gas produced by the cryogenic separation method, was used as the foaming gas.

The total concentration of nitrogen and argon in the foaming gas was 99.995%. Since the cryogenic separation method can remove argon, little or no argon remains in the foaming gas, and its concentration is less than 0.1%.

2. Evaluation

Cross-sectional photographs of the foam molded body of Example 1 and Comparative Example 1 are shown in FIG. **3**A and FIG. **3**B. As shown in FIG. **3**A and FIG. **3**B, the foam molded body of Example 1 has a significantly higher roundness of bubbles than the foam molded body of Comparative Example 1.

Furthermore, each of the surface roughness (Ra) in the foam molded bodies of Example 1 and Comparative Example 1 was measured. As a result, the surface roughness (Ra) was 8.5 μm in Example 1 and 9.6 μm in Comparative Example 1. This result indicates that the foam molded body of Example 1 has a smoother surface than the foam molded body of Comparative Example 1.

REFERENCE SIGN LIST

1: foam blow molding machine, **2**: pipe, **11**: raw material resin, **11***a*: melt-kneaded resin, **12**: hopper, **13**: extruder, **13***a*: cylinder, **14**: gas supply device, **15**: nitrogen gas generation unit, **15***a*: compressor, **15***b*: tank, **15***c*: nitrogen gas generator, **15***d*: buffer tank, **15***e*: compressor, **15***f*: buffer tank, **16**: injector, **17**: accumulator, **17***a*: cylinder, **17***b*: piston, **18**: head, **19**: split mold, **23**: foam parison, **25**: joint pipe, **27**: joint pipe

The invention claimed is:

1. A method for manufacturing a foam molded body, comprising

a step of forming a foam parison by melting and kneading a raw material resin and a foaming gas in a cylinder of an extruder to obtain a melt-kneaded resin,

storing the melt-kneaded resin in a cylinder of an accumulator, and

after a predetermined amount of the melt-kneaded resin is stored in the cylinder of the accumulator, moving a piston of the accumulator to extrude the melt-kneaded resin from a die slit provided in a head, and

a step of molding the foam parison using split molds to obtain the foam molded body, wherein the molding is a blow molding in which the foam parison is molded by blowing air into cavity of the split molds, and the foaming gas is a gas obtained by removing oxygen from air with an absorbent, wherein the cylinder is provided with an injector for injecting the foaming gas into the cylinder, the gas supply device is connected to the injector via a pipe, the gas supply device includes a nitrogen cylinder and a nitrogen gas generation unit which removes oxygen from air by using the adsorbent; and the pipe is branched so as to be connected to both of the nitrogen cylinder and the nitrogen gas generation unit.

* * * * *